

## **I. INTRODUCTION**

### **A. PURPOSE**

The primary purpose of this report is to develop a state-of-the-science assessment of air quality and air pollution effects to support National Park Service (NPS) mandates under the Organic Act, the Clean Air Act (CAA), and other pertinent laws and policies to conserve, restore, and protect Shenandoah National Park's (SHEN) resources for current and future generations. This technical assessment is necessary to:

- enhance NPS and SHEN ability to meet “affirmative responsibility” obligations at national, regional, state, and park levels through effective synthesis of relevant data and information;
- enhance scientific understanding and quantification of key air pollutant emissions, transport, deposition, and current and projected future effects on SHEN resources;
- update a related 1990 technical document and quantify the range of critical loads of air pollutants;
- develop visual and ecological models and other educational tools aimed at non-technical audiences;
- provide state-of-science information for park staff, and in preparation for revision of the SHEN General Management Plan; and
- determine SHEN-specific acidic deposition analysis thresholds for New Source Review.

This assessment can also serve as a sub-regional case study regarding Class I area restoration and protection issues for those engaged in collaborative regional and state planning, policy-making, permit review, and scientific activities in the eastern United States. This information will be used for strategic outreach to key decision-makers and stakeholders in the development of regional and state air pollution control strategies and plans. Park managers and resource professionals will also use this assessment to communicate information regarding SHEN air quality and resource conditions to park employees and key local partners and other stakeholders, and to promote pollution prevention practices in the park. To support the NPS mandate to protect air quality related values (AQRVs) in Class I areas, the following specific objectives have been identified for the report:

- provide updated summaries of monitoring data on visibility, pollutant concentrations, and deposition, both temporally and spatially;

- conduct comprehensive analyses of documented and potential ecological effects of various atmospheric pollutants and exposures (chronic, episodic) on terrestrial and aquatic systems;
- summarize national ambient air quality standards (NAAQS) exceedances and potential non-attainment designation;
- utilize existing emissions inventories, meteorological data, and atmospheric models to assess current and future air quality conditions;
- utilize existing atmospheric deposition and terrestrial and aquatic effects models to evaluate potential future changes in air quality, deposition, and associated impacts;
- compile inventories of pollution-sensitive components or receptors of ecosystems, and assess the critical loading of pollutants that would be likely to cause changes in the sensitive receptors.

The report addresses these objectives by providing a summary of current and historical monitoring data for pollutants, a description of the resource base in the park, a synthesis of knowledge on the visual and ecological effects of atmospheric pollutants, model estimates of future atmospheric deposition associated with various emissions control scenarios, model estimates of future changes in the extent of streamwater acidification and associated effects on native brook trout (*Salvelinus fontinalis*) and species richness of aquatic biota, model estimates of potential future ground-level (tropospheric) ozone (O<sub>3</sub>) effects on individual tree species and forest stands, and a park-specific assessment of pollution vulnerability and current and potential future impacts. The approach relies on published data summaries, new analyses, model output, journal articles, and technical reports. Some original data collection activities occurred in conjunction with this project; specifically, soils samples were collected and analyzed from 79 sites within the park during the summer of 2000.

This report is intended to serve diverse audiences, including various NPS, U.S. Fish and Wildlife (USFWS), and U.S. Forest Service (USFS) staff, state and Federal air regulators and scientists, regional planning organizations, conservation groups, industries, and others actively engaged in air quality issues in Virginia and throughout the eastern United States.

## **B. BACKGROUND**

The NPS maintains the world's most admired system of national parks. The mission of the NPS is to preserve unimpaired the natural and cultural resources and values of the national park

system for the enjoyment, education, and inspiration of this and future generations. Air quality is fundamentally important to the preservation of these resources and values. In the 1977 Amendments to the Federal CAA, Congress formally recognized this when defining one of the purposes of the CAA, "...to preserve, protect and enhance the air quality in national parks, national wilderness areas, national monuments, national seashores and other areas of special national or regional natural, recreational, scenic, or historic value." Congress also designated 48 national parks managed by the NPS (including Shenandoah) and 108 wildernesses managed by the USFWS or the USFS as "mandatory Class I areas". The 1977 CAA outlined several special protections for Class I areas related to visibility and the prevention of significant deterioration of air quality and adverse impacts on Class I AQRVs. AQRVs include visibility, flora, fauna, bodies of water, soils, and other natural and cultural resources that may potentially be damaged by air pollution. Congress also delegated to Federal Land Managers (FLMs) "...an affirmative responsibility to protect the air quality related values...within a Class I area." The CAA legislative history further instructs FLMs "...to err on the side of protecting air quality related values for future generations". The 1990 CAA Amendments (CAAA) upheld and strengthened this affirmative responsibility and special protections afforded Class I areas.

In the late 1970s, the NPS responded to its new "affirmative responsibility" charge by forming a national Air Resources Division (ARD), staffed with air policy and technical experts, to assist Class I national parks with obtaining, analyzing and interpreting high-quality data to be used in the air policy-making, scientific, and educational arenas. Knowledge of pertinent laws, regulations, and policies, coupled with knowledge of emission inventories and scientific understanding of the effects of pollutants on park resources, provides the NPS with a framework to protect sensitive park resources from degradation due to air pollution.

Shenandoah National Park in Virginia (Figure I-1) is located downwind from and near major industrial and urban areas. The ARD targeted SHEN as one of the earliest atmospheric deposition, visibility, and air quality monitoring sites in the Class I national park network. In the early 1980s, SHEN

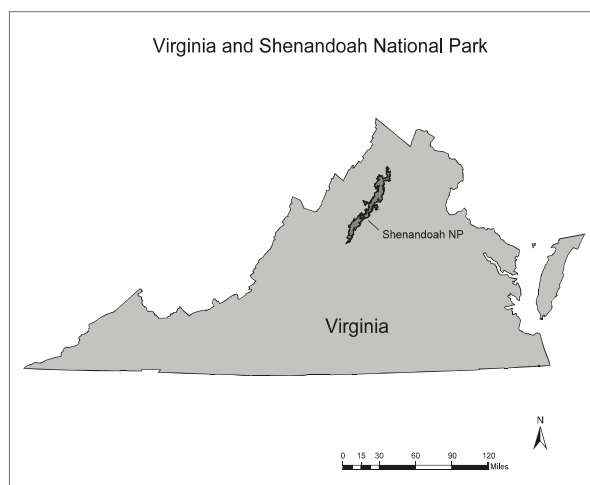


Figure I-1. Locational map for SHEN.

began long-term monitoring of ground-level O<sub>3</sub>, sulfur (S) and nitrogen (N) wet deposition, and the size (coarse and fine), concentration, and chemical composition of airborne particulate matter that degrades visibility. The park's long-term monitoring program has since been expanded to include meteorology, sulfur dioxide (SO<sub>2</sub>), dry deposition, visibility optical (e.g., light extinction and light scattering) monitoring, and (effective October, 2002) wet deposition of mercury. SHEN has also benefitted from a five-year photographic visibility monitoring project, a five-year research-grade O<sub>3</sub> precursor (nitrogen oxides [NO<sub>x</sub>] and volatile organic compounds) study, and research projects related to visibility, cloud chemistry, streamwater chemistry, acidic deposition effects on fish, and O<sub>3</sub> effects on sensitive vegetation. In 1979, SHEN began a long-term cooperative agreement with acidic deposition scientists at the University of Virginia to monitor the acid-base status of two park streams and wet deposition in their respective watersheds. The Shenandoah Watershed Study's (SWAS) streamwater chemistry monitoring program was expanded to 14 streams by the mid-1990s. Today, SHEN maintains one of the most comprehensive long-term atmospheric deposition, air quality and related values (e.g., visibility and streamwater acid-base status) monitoring programs of the 48 Class I national parks. SHEN's strong scientific foundation, coupled with a solid legal and policy foundation (Section I.C), enhances NPS capability to uphold its "affirmative responsibility" to restore and protect key AQRVs in SHEN from the harmful effects of human-caused air pollution.

As described in this report, long-term monitoring and short-term research projects at SHEN testify that human-caused air pollution has adversely impacted the park's air quality, visibility, streamwater chemistry, and native fish at the individual, population, and community levels. Visibility has been significantly degraded, potentially detracting from visitor enjoyment of numerous vistas accessible from Skyline Drive (a Virginia State Scenic Highway), the Appalachian National Scenic Trail, and other trails and points within the park. Despite improvements in air quality under the CAA, the park's visibility and sensitive aquatic systems are still adversely impacted relative to estimated natural or pre-industrial background conditions (Church et al. 1992, Herlihy et al. 1993, Pitchford and Malm 1994, U.S. EPA 1995, Bulger et al. 2000, Malm et al. 2000, Stoddard et al. 2003) and, along with other Class I areas in the northeast and southeast, will remain at risk after full implementation of the 1990 CAAA. SHEN still suffers among the highest O<sub>3</sub> levels recorded at Class I national parks. Since the late 1980s, summertime ground-level O<sub>3</sub> at SHEN has consistently exceeded levels that are harmful to vegetation. Ozone foliar injury has been documented on several of the 40 known O<sub>3</sub>-sensitive

plant species found at SHEN, and there is concern about potential effects of O<sub>3</sub> on forest growth and health. Visitor experience and visitor and employee health and safety are, or can be, impaired when summertime O<sub>3</sub> exposures exceed the human health protection standards established by the U.S. Environmental Protection Agency (U.S. EPA).

Based on a 1990 NPS technical assessment of air pollution impacts at SHEN, miscellaneous peer-reviewed literature and technical reports, and NPS air quality trends reports initiated in the late 1990s, it was evident that the NPS may not effectively uphold its “affirmative responsibility” to restore and protect SHEN AQRVs from adverse impacts of human-caused air pollution without an integrated state-of-the-science assessment. In early 1998, University of Virginia scientists notified SHEN of a pending report (Bulger et al. 1998) and paper (Bulger et al. 2000) that employed watershed acidification modeling to project substantial 1990 CAAA shortcomings in protecting and restoring the highly-prized, relatively acid-tolerant Appalachian brook trout (*Salvelinus fontinalis*) in some of the 65 streams (including 14 park streams) monitored in western Virginia. At the time, there was also uncertainty about the outcome of the Southern Appalachian Mountains Initiative’s (SAMI) voluntary, consensus-based, multi-stakeholder effort to prepare an integrated regional assessment of air pollution effects on the vistas, streams, and forests of the southern Appalachians in eight states including Virginia. The goal of SAMI was to “recommend reasonable measures to remedy existing and prevent future adverse effects from human-induced air pollution”. The park, recognized as a national example of significant air pollution impacts, obtained ARD support to acquire NPS Natural Resource Protection Program funds for this integrated, state-of-the-science SHEN Assessment. Park management and ARD support was based in large part on an understanding that this project would add value to the regional SAMI effort by providing:

- in-depth, park-specific data analyses and synthesis that capitalize on SHEN’s comprehensive, high quality data sets, including new soils data collected within this project;
- airshed approach to determine SHEN-specific visibility, S and N deposition impacts, and state and source subregion contributions toward those impacts;
- landscape approach to assess SHEN-specific ground-level O<sub>3</sub> forest effects;
- defensible, SHEN-specific critical loads of air pollutants, enhanced in the case of S deposition by new soils data;

- objective disclosure of the environmental consequences at SHEN of two “On the Books” emissions scenarios based on the 1990 CAAA and two substantially more stringent emissions scenarios responsive to key known SHEN issues (e.g., visibility, acidic deposition, ground-level O<sub>3</sub>); and
- objective disclosure of the current condition of SHEN AQRVs and prognosis for recovery under already promulgated regulations and SHEN Assessment emissions scenarios.

Long-range transport is involved with each of the pollutants of concern affecting SHEN, especially the secondary pollutants responsible for acidic deposition and visibility degradation, but also for O<sub>3</sub>. Nonetheless, this SHEN Assessment (Section IV-C) and the final SAMI (2002) report both confirm that states are important contributors to air quality and air pollution impact problems within their own boundaries. Emissions from local sources within about 200 km produce greater haze- and acid-forming pollutants at receptors in SHEN (*on a per ton emissions basis*) than those farther away. The SAMI (2002) report also concluded that Class I areas in the central part of the eight-state SAMI region (e.g., Tennessee and North Carolina) would benefit the most from voluntary implementation of the SAMI emissions control scenarios. SHEN is greatly impacted by emissions from Great Lake states, mid-Atlantic states, and southeastern States (see Section IV-C), and is located between the borders of the respective regional planning areas for those states. The park’s geographic location and impacted status demonstrates the need for significant trans-boundary communication and multi-stakeholder collaboration in development of clean air strategies. Since there are relatively few Class I national parks or wilderness areas in the eastern United States, the SHEN Assessment can serve as a “subregional case study” in the air policy, planning, scientific, and educational arenas at national, regional, and state levels. This assessment will also be a valuable tool in the park’s resource stewardship, science, interpretation, education, and outreach programs.

### **C. LEGAL RESPONSIBILITIES AND MANAGEMENT POLICIES**

The following is an explanation of how the NPS Organic Act, the CAA (as amended in 1977 and 1990), other pertinent environmental laws, and policies relate to air resource management on NPS lands, including SHEN. Key elements of these laws and policies are summarized below.

## **1. National Park Service Organic Act**

In 1916, Congress created a new Federal agency in the U.S. Department of the Interior (DOI), the NPS, to manage and protect the National Park System. The general mandate of the 1916 Organic Act states that the NPS will:

"promote and regulate the use of...national parks...by such means and measures as conform to the fundamental purpose of the said parks...which purpose is to conserve the scenery and the natural and historic objects and wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (16 USC 1).

The Organic Act and its 1970 and 1978 amendments do not directly address air pollution effects; however, they do specify what resources should be protected in the National Park System. The 1978 amendments further clarify the importance Congress placed on protecting park resources:

"The authorization of activities shall be construed and the protection, management, and administration of these areas shall be conducted in light of the high public value and integrity of the National Park System and shall not be exercised in derogation of the values and purposes for which these various areas have been established, except as may have been or shall be directly and specifically provided by the Congress" (16 USC 1a-1).

## **2. Enabling Legislation for Shenandoah National Park**

Interest in preserving lands in the southern Appalachians actually began even before the Organic Act was established. Shortly after the creation of the NPS in 1916, Director Stephen T. Mather began studying and advocating the creation of national parks in the East. In 1923, he proposed that a typical section of the Appalachian Mountains be established as a national park. In 1924, the Secretary of the Interior appointed the Southern Appalachian National Park Committee to investigate the possible existence of sites suitable for the establishment of such a park. The Committee commented as follows in their 1924 report:

"The Blue Ridge of Virginia, one of the sections which had your committee's careful study, while secondary to the Great Smokies in altitude and some other features, constitute [sic], in our judgement, the outstanding and logical place for the creation of the first national park in the southern Appalachians.

It will surprise the American people to learn that a national park site with fine scenic and recreational qualities can be found within a three-hour ride of our National Capitol and within a day's ride of 40,000,000 of our inhabitants. It has many canyons and gorges, with beautiful cascading streams. It has some

splendid primeval forests, and the opportunity is there to develop an animal refuge of national importance... this area is full of historic interest, the mountains looking down on valleys with their...battlefields of Revolutionary and Civil War periods...and the birthplaces of many...Presidents...

The greatest single feature, however, is a possible sky-line drive along the mountain top following a continuous ridge and looking down westerly on the Shenandoah Valley...and also commanding a view of the Piedmont Plain stretching easterly to the Washington Monument, which landmark of our National Capitol may be seen on a clear day. Few scenic drives in the world could surpass it."

Shortly following the Committee's report, an effort to formally establish SHEN began.

The enabling legislation for SHEN was passed in 1926 and provided for management and protection of the park by the NPS under the direction of the Secretary of the Interior, subject to the provisions of the 1916 NPS Organic Act, and subject to exemption from the 1920 Federal Water Power Act. SHEN was not actually created until 1935, after sufficient lands were acquired and donated by the Commonwealth of Virginia. The remainder of this section provides more specific legal (NPS 1994) and policy (NPS 2000a,b; SHEN 2001) information guiding an integrated approach to air resource management at SHEN.

### **3. Government Performance and Results Act**

The 1993 Government Performance and Results Act was enacted to bring the Federal government into a contemporary performance management system that is mission- and results-oriented. This law requires Federal agencies to develop: 1) a Strategic Plan, 2) Annual Performance Plans, and 3) Annual Performance Reports in order to more effectively and efficiently manage their activities to achieve their missions, and to more effectively communicate with the Congress and the American people. The NPS developed its first Strategic Plan in 1997. Key NPS mission goals related to air resource management include:

- Natural and cultural resources and associated values are protected, restored, and maintained in good condition and managed within their broader ecosystem and cultural context, and
- NPS contributes to knowledge about natural and cultural resources and their associated values; management decisions about resources and visitors are based on adequate scholarly and scientific information.



The current NPS Strategic Plan is available on the internet at <http://planning.den.nps.gov>. The current Annual Performance Report for the NPS Air Quality Program is also available on the internet at <http://www2.nature.nps.gov/ard>.

Air pollution and associated resource impacts are integral parts of SHEN's Resource Management Plan and Strategic Management Plan. The Mission Statement of the park's Strategic Management Plan that was first developed in 1997 is:

"Shenandoah National Park restores, where appropriate, and maintains the park as a functioning ecosystem that is the outstanding representative of the Blue Ridge/Central Appalachian biome. The park provides present and future generations outstanding opportunities to experience "recreation and re-creation" by driving the Skyline Drive, walking the Appalachian Trail and related trails, or experiencing the backcountry wilderness areas. The park preserves the fabric and tells the stories of the people and the land both before the park was established and as a result of the establishment of the park."

The SHEN Mission Goals most pertinent to air resource management include:

- Ecological integrity of this portion of the Blue Ridge/Central Appalachian biome is protected, maintained and restored as appropriate.
- Views of the Shenandoah Valley and Piedmont Plain, as seen from the park, are scenic and rural in character, and maintained in partnership with and integrating the needs of the surrounding communities.
- Visitors safely enjoy and are satisfied with the availability, accessibility, diversity and quality of park facilities; services; and appropriate recreational and "re-creational" opportunities.

Air resources and related values are also integral parts of the park's interpretation, education, and outreach programs. The SHEN Comprehensive Interpretive Plan (SHEN 2001) identifies primary parkwide interpretive themes that define the most important ideas or concepts to be communicated to the public about the park:

Primary Theme A. "Shenandoah National Park is a managed land area, representative of the central Appalachian biome, where science and law are the basis for making informed decisions to protect natural and human values inherent in the ecosystem."

Primary Theme B. "Shenandoah National Park was created and developed to bring the traditional national park experience to the densely populated east, and thereby generate support for the NPS mission of preserving America's heritage for all to enjoy."

#### **4. Clean Air Act**

The CAA of 1970 was enacted to protect public health and welfare from the harmful effects of human-made air pollution. Criteria pollutants are those pollutants for which the U.S. EPA has established NAAQS as directed by the CAA (Table I-1). Standards were established for the pollutants that are emitted in significant quantities throughout the country and that may endanger public health and welfare. The primary NAAQS are designed to protect human health while the secondary NAAQS are designed to protect public welfare from the adverse effects of the pollutant. The CAA defines public welfare effects to include, but not be limited to, "effects on soils, water, crops, vegetation, manmade materials, animals, wildlife, weather, visibility and climate, damage to and deterioration of property, and hazards to transportation, as well as effects on economic values and on personal comfort and well-being." The standards are defined in terms of deposition averaging times, such as annual or hourly, depending on the type of exposure associated with health and welfare effects. For some pollutants, there are both short-term and long-term standards. Criteria pollutants include O<sub>3</sub>, carbon monoxide (CO), nitrogen dioxide (NO<sub>2</sub>), SO<sub>2</sub>, particulate matter less than 10 µm (PM<sub>10</sub>), particulate matter less than 2.5 µm (PM<sub>2.5</sub>), and lead. Data on criteria pollutants collected by a national monitoring system are used to determine if the NAAQS are met and to track pollutant trends. On July 17, 1997, the U.S. EPA announced changes to the NAAQS for O<sub>3</sub> and particulate matter. The U.S. EPA is phasing out the 1-hour O<sub>3</sub> standard, and replacing it with an 8-hour standard. For particulate matter, a standard for PM<sub>2.5</sub> has been added while retaining the PM<sub>10</sub> standard. The U.S. EPA determined that these changes were necessary to protect public health and the environment.

In order to protect human health and welfare, the U. S. EPA has established primary and secondary O<sub>3</sub> NAAQS for maximum allowable O<sub>3</sub> concentration levels. Prior to 1997, these standards were based upon 1-hour average O<sub>3</sub> measurements. They were revised in 1997, when the U.S. EPA promulgated new standards, both primary and secondary, based upon an 8-hour average value. Under this rule, the annual fourth-highest daily maximum 8-hour O<sub>3</sub> concentration, averaged over three years, must not exceed 0.08 ppm (parts per million; 80 ppbv, which can be rounded up to 85 ppbv). This average is computed by first determining the highest 8-hour average O<sub>3</sub> value for each day of the year, and then identifying the 4<sup>th</sup>-highest of all daily maximum 8-hour O<sub>3</sub> values that occurred during the year. These 4<sup>th</sup>-highest values are then averaged over three successive years to determine the final concentration value that is compared to the standard. Because of rounding procedures, the U.S. EPA has indicated that 85 ppbv is the

Table I-1. National Ambient Air Quality Standards, published by the U.S. Environmental Protection Agency, in connection with the Clean Air Act and 40 CFR, Part 50.				
Pollutant	Primary Standard		Secondary Standard	
	ug/m <sup>3</sup>	ppm	ug/m <sup>3</sup>	ppm
<b>Carbon Monoxide</b> 8-hour concentration 1-hour concentration	10,000 <sup>a</sup> 40,000 <sup>a</sup>	9 <sup>a</sup> 35 <sup>a</sup>		
<b>Sulfur Dioxide</b> Annual arithmetic mean 24-hour concentration 3-hour concentration	80 365 <sup>a</sup>	0.03 0.14 <sup>a</sup>	1300 <sup>a</sup>	0.50 <sup>a</sup>
<b>Nitrogen Dioxide</b> Annual arithmetic mean	100	0.053	Same as primary	
<b>Ozone</b> 8-hour concentration 1-hour concentration	157 <sup>b</sup> 235 <sup>c</sup>	0.08 <sup>b</sup> 0.12 <sup>c</sup>	Same as primary	
<b>Lead</b> Quarterly arithmetic mean	1.5		Same as primary	
<b>Particulate Matter</b> <b>PM<sub>2.5</sub></b> Annual arithmetic mean 24-hour concentration <b>PM<sub>10</sub></b> Annual arithmetic mean 24-hour concentration	15 <sup>d</sup> 65 <sup>e</sup>  50 <sup>d</sup> 150 <sup>f</sup>		Same as primary	
<sup>a</sup> Not to be exceeded more than once a year <sup>b</sup> 3-year average of the 4th highest 8-hour concentration may not exceed 0.08 ppm <sup>c</sup> Areas in nonattainment with the 1-hour standard must meet that standard before demonstrating attainment with the 8-hour standard. <sup>d</sup> Based on a 3-year average of annual averages <sup>e</sup> Based on a 3-year average of annual 98th percentile values <sup>f</sup> Based on a 3-year average of annual 99th percentile values				

lowest concentration that would exceed the 80 ppbv standard. The new secondary standard is identical to the primary standard.

The CAA (1977 Amendments) designated all national parks over 6,000 acres that were in existence as of August 7, 1977, as mandatory "Class I" areas. All other parks in existence at that time and all parks established since this date are designated as "Class II", regardless of size. Class I areas, including SHEN, are afforded the greatest degree of air quality protection. The CAA assigns FLMs of Class I areas:

"...an affirmative responsibility to protect air quality related values from adverse impacts due to manmade air pollution" (42 USC #7475(d)(2)(B))

The CAA legislative history further instructs FLMs to:

"...assume an aggressive role in protecting the air quality related values of Class I areas from adverse impact...In cases of doubt the land manager should err on the side of protecting the air quality related values for future generations." (Senate Report No. 95-127, 95<sup>th</sup> Congress, 1<sup>st</sup> Session, 1977)

Congress placed special emphasis on visibility protection by setting a National Visibility Goal in the CAA:

"...the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Class I Federal areas which impairment results from man-made air pollution..." (Section 169A(a)(1))

The 1977 amendments also require states to specifically address this goal in their State Implementation Plans (SIP), and to include Best Available Retrofit Technology (BART) for the appropriate emission sources.

The CAA as amended in 1977 also established the Prevention of Significant Deterioration (PSD) program. The primary objective of the PSD provisions is to prevent substantial degradation of air quality in areas that comply with NAAQS, and yet maintain a margin for industrial growth. A PSD permit from the appropriate air regulatory agency is required to construct a new pollution source or modify an existing source (Bunyak 1993). A permit application must demonstrate that the proposed polluting facility will 1) not violate national or state ambient air quality standards, 2) use the best available control technology to limit emissions, 3) not violate either Class I or Class II PSD increments for SO<sub>2</sub>, NO<sub>2</sub>, or particulate matter (Table I-2), and 4) not cause or contribute to adverse impacts to AQRVs in any Class I area (Peterson et al. 1992). The PSD increments are allowable pollutant concentrations that can be added to baseline concentrations.

The values chosen as PSD increments by Congress were not selected on the basis of concentration limits causing impacts to specific resources. Therefore, it is possible that pollution increases exceeding the legal Class I increments may not cause damage to Class I areas. It is also possible that resources in a Class I area could be adversely affected by pollutant concentrations that do not exceed the increments. The role of the FLM is to determine if there is potential for additional air pollution to cause damage to sensitive receptors whether or not the

Table I-2. Prevention of significant deterioration increments (in $\mu\text{g}/\text{m}^3$ ). <sup>a</sup>				
Constituent	Averaging Time	Class I	Class II	Class III
Sulfur Dioxide	Annual Arith. Mean	2	20	40
	24-hour	5	91	182
	3-hour	25	512	700
PM <sub>10</sub>	Annual Arith. Mean	4	17	34
	24-hour	8	30	60
Nitrogen Dioxide	Annual Arith. Mean	2.5	25	50
<sup>a</sup> PSD increments are not defined for ozone, PM <sub>2.5</sub> , lead, or carbon monoxide.				

PSD increments have been exceeded. Even if a proposed facility is not expected to violate Class I increments, the FLM can still recommend denial for a permit by demonstrating that there will be adverse impacts in the Class I area. Provisions for mitigation can be recommended by the FLM to the agency that issues permits.

The following questions may be addressed when reviewing PSD permit applications:

- What are the identified sensitive AQRVs in each Class I area that could be affected by the new source?
- What are the air pollutant levels that may affect the identified sensitive AQRVs?
- Will the proposed facility result in pollutant concentrations or atmospheric deposition that will cause the identified critical level to be exceeded or add to levels that already exceed the critical level?
- If the critical level is exceeded, what amount of additional pollution is considered "insignificant"?

The first two questions are largely land management issues that should be answered on the basis of management goals and objectives for the Class I area. The last two are technical and policy questions that must be answered on the basis of analyses of projected emissions from the proposed facility and predictions of environmental response to given pollutant concentrations (Peterson et al. 1992).

The U.S. EPA promulgated regulations in 1980 to address visibility impairment that is "reasonably attributable" to one or a small group of sources. Congress subsequently added section 169B as part of the CAA 1990 Amendments to focus attention on regional haze issues. On July 1, 1999, the U.S. EPA promulgated the Regional Haze Rule (RHR), which requires states (and tribes who choose to participate) to review how pollution emissions within the state

affect visibility at "Class I" areas across a broad region (not just Class I areas within the state). These rules also require states to make "reasonable progress" in reducing any effect this pollution has on visibility conditions in Class I areas and to prevent future impairment of visibility. The states are required by the rule to analyze a pathway that takes the Class I areas from current conditions to "natural conditions" in 60 years. "Natural conditions" is a term used in the CAA, which means that no human-caused pollution can impair visibility. This program, while aimed at Class I areas, will improve regional visibility throughout the country. In 2002, industry successfully challenged the BART portion of the RHR, which addresses older industrial sources. The U.S. EPA is currently in the process of updating that portion of the rule.

In Title IV of the 1990 CAAA, Congress called for the decrease of annual emissions of SO<sub>2</sub> and NO<sub>x</sub> from utilities burning fossil fuels. The legislation specifically required a 10 million ton reduction (from 1980 levels) in annual SO<sub>2</sub> emissions and a 2 million ton reduction in NO<sub>x</sub> emissions from utilities by the year 2010.

## **5. Clean Air Act Implementation Developments**

On September 18, 1990, a preliminary notice of adverse impact on SHEN was published in the *Federal Register* by the Office of the Secretary, U.S. DOI (U.S. Dept. Interior 1990). This notice announced the preliminary determination by the Assistant Secretary for Fish and Wildlife and Parks, as the FLM of SHEN, that in accordance with the PSD air quality requirements of the CAA, the air pollution emissions from a proposed major emitting facility (1 of 19 new power plants proposed near the park) could contribute to or exacerbate adverse impacts on the AQRVs of this PSD Class I area. The FLM also recommended that the Virginia Department of Air Pollution Control not issue a permit to the facility unless measures were taken to ensure that this proposed source would not contribute to adverse impacts on park resources.

A technical support document was prepared by the ARD of the NPS and by SHEN in September 1990 in support of the adverse impact determination (National Park Service 1990). That review document supported the FLM's preliminary determination that:

“although the Class I increments may not be exceeded at Shenandoah National Park, the increase in emissions resulting from the proposed PSD facilities will, together with the already permitted emissions, have an unacceptable adverse impact on visibility and other air quality related values in Shenandoah National Park. Visibility, aquatic, and terrestrial resources at Shenandoah National Park are currently being adversely affected by air pollution. The FLM reasonably believes that the effects of the additional sulfur dioxide, nitrogen oxide, and

volatile organic compounds emissions associated with the electric generating stations proposed for the area would contribute to and exacerbate the existing adverse effects and are therefore unacceptable. In particular, increases in SO<sub>2</sub> and NO<sub>x</sub> emissions associated with the pending permit applications are highly likely to (1) exacerbate existing adverse visibility conditions at Shenandoah National Park and cause a perceptible further degradation in park visibility; (2) hasten the acidification of sensitive streams within the park, with resulting effects on aquatic life; and (3) threaten sensitive park vegetation. The proposed increases in VOC and NO<sub>x</sub> emissions will contribute to already high ozone levels, at times already higher than the national standard, and impacts on ozone sensitive vegetation.”

The Virginia Department of Air Pollution Control issued a permit to the major emitting facility and it was appealed by environmental groups. The source was never built. Adverse impact determinations at SHEN (1990) and the Great Smoky Mountains National Park (1992) triggered the creation of two collaborative air quality planning bodies, SAMI (SAMI 2002) and the Interagency Work Group on Air Quality Models (U.S. EPA 1998a). In 1993, the NPS entered into a Memorandum of Understanding (MOU) with the Virginia Department of Air Pollution Control (since renamed the Virginia Department of Environmental Quality) regarding air permitting procedures. Although this MOU expired in 1998, the Virginia Department of Environmental Quality continues to honor its provisions at this writing.

In May 1998, the U.S. EPA issued the Interim Air Quality Policy on Wildland and Prescribed Burning, for FLMs and air regulators. Objectives of the new policy include avoidance of public health effects from increased prescribed burning and improvement of visibility in Class I areas. States are required by the policy to develop Smoke Management Programs. Virginia issued revised Smoke Management Guidelines in June 1998. The objectives of Virginia’s guidelines were to: 1) identify and avoid smoke-sensitive areas, 2) reduce emissions, and 3) disperse and dilute smoke before it reaches smoke-sensitive areas. Air resource and fire management specialists are cooperating on a revision to the 1993 SHEN Fire Management Plan to ensure consistency with current air regulatory policies, regulations, and prescribed burning permitting requirements. In May 2001, Federal and state air regulators and FLMs agreed that natural fire emissions baselines required under the Regional Haze Rule would include certain amounts and types of management ignitions.

In June 2000, Virginia recommended to the U.S. EPA that about one-third of SHEN (parkland only in Page and Madison counties) be designated as a preliminary O<sub>3</sub> nonattainment area per the 1997 O<sub>3</sub> 8-hour NAAQS and 1997-1999 O<sub>3</sub> levels recorded at the park’s monitor at

Big Meadows. The U.S. EPA presumptive nonattainment boundaries included an additional 10% of parkland in Warren County for a total (Virginia and U.S. EPA) of 43% of the park. In May 2001, the U.S. Supreme Court generally upheld the U.S. EPA's 1997 O<sub>3</sub> 8-hour and PM<sub>2.5</sub> NAAQS but delayed implementation until EPA addressed certain remanded issues. The U.S. EPA resolved these issues and established a final deadline of July, 2003 for recommendations from the states regarding O<sub>3</sub> nonattainment, and a deadline of July, 2004 for official designations by the U.S. EPA. In November, 2002, Virginia reaffirmed the Commonwealth's intent to recommend to the U.S. EPA in 2003 that the Page and Madison County portions of SHEN be designated as an O<sub>3</sub> nonattainment area. If Virginia or the U.S. EPA officially designates any of the park as an O<sub>3</sub> nonattainment area, SHEN managers must ensure that transportation and general management projects emitting O<sub>3</sub> precursors in the affected area are in compliance with Virginia's plan to attain and maintain the 8-hour O<sub>3</sub> standard.

On July 19, 2000, the U.S. DOI requested that the U.S. EPA initiate a rulemaking proceeding to restore and protect AQRVs in national parks and wilderness areas. Subsequently, the U.S. EPA posted a notice in the *Federal Register* soliciting public comments on the rulemaking requests from the U.S. DOI and several northeastern states (65 Fed. Reg. 48699-48701). Technical support documents were prepared by the NPS (NPS 2000c) and the USFWS and submitted to the U.S. EPA on December 6, 2000. These documents synthesized available scientific information regarding air pollution effects on natural resources in several units of the National Park System (including SHEN) and National Wildlife Refuge System. The NPS has observed chronic and episodic acidification of streams in both SHEN and Great Smoky Mountains National Park, as well as foliar injury from O<sub>3</sub> and visibility impairment in many park units. For further information, see the supporting technical documents at [www2.nature.nps.gov/ard/epa](http://www2.nature.nps.gov/ard/epa). The NPS continues to work with the U.S. EPA to address Class I AQRV issues.

As indicated in Table I-1, secondary NAAQS for all criteria pollutants have not been proposed. Instead, the U.S. EPA has offered other policy tools to supplement NAAQS secondary implementation. For example, the 1997 O<sub>3</sub> 8-hour and PM<sub>2.5</sub> NAAQS were supplemented with the 1998 NO<sub>x</sub> SIP Call, the 1999 Regional Haze Rule, and the 2001 BART Rule. In addition, for O<sub>3</sub> secondary NAAQS, the U.S. EPA has also committed to sponsoring additional research regarding effects of O<sub>3</sub> on sensitive vegetation. It is not known at this time if the EPA will promulgate secondary standards for any of the other criteria pollutants.



## **6. Federal Water Pollution Control (Clean Water) Act**

The Clean Water Act is summarized here because, like the Clean Air Act, it provides an additional tool to help the park meet NPS Organic Act mandates as well as NPS and SHEN management policies (I.C.8-9). The impaired streams and antidegradation sections of this law are pertinent to this assessment. Several acidified park streams may qualify for impaired streams listing and several others may be designated by Virginia as exceptional waters.

The Federal Water Pollution Control Act, commonly known as the Clean Water Act, was promulgated in 1972, and significantly amended in 1977, 1987, and 1990. The primary purpose of the act is to protect and to restore the physical, chemical, and biological quality of the nation's waters. Goals established by the act are to make all navigable waters "fishable and swimmable", and to eliminate the discharge of pollutants into the nation's waterways.

Congress recognized the primary role of the individual states in managing and regulating the quality of the nation's waters under the general framework provided by the Clean Water Act, and further defined by U.S. EPA regulations. All Federal agencies must comply with the requirements of state law for water quality management, regardless of other jurisdictional status or land ownership.

States manage and protect water quality through the development and enforcement of ambient water quality standards. Water quality standards are composed of the following three interrelated parts: 1) designated beneficial uses of a waterbody, such as contact recreation or cold water fishery; 2) numerical or narrative criteria that establish the limits of physical, chemical, and biological characteristics of water sufficient to protect beneficial uses; and 3) an antidegradation provision to protect water quality that exceeds criteria and to protect and maintain water quality in "Outstanding National Resource Waters", including certain waters in national parks and wildlife refuges. States comply with water quality standards by controlling the type and quantity of point source pollutants entering waters through the National Pollutant Discharge Elimination System, and implementing Best Management Practices for nonpoint sources of pollution. Section 303(d) of the act requires states to also formally identify waters that do not currently meet water quality standards, and bring them into compliance through the development and implementation of Total Maximum Daily Loads (TMDLs). The TMDL establishes the maximum loadings of pollutants that a waterbody can receive from point and nonpoint (including atmospheric deposition) sources of pollution without exceeding the standards.

Water quality standards for Virginia are developed and promulgated by the Virginia Department of Environmental Quality through the Virginia Administrative Code. Virginia has designated all of its waters for the following uses: recreational uses, e.g., swimming and boating; the propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish.

Virginia's numeric criteria for three important parameters, dissolved oxygen, pH, and maximum temperature, are variable and categorized into the following "classes":

- I. Open Ocean
- II. Estuarine Waters (Tidal Water- Coastal Zone to Fall Line)
- III. Nontidal Waters (Coastal and Piedmont Zones)
- IV. Mountainous Zone Waters
- V. Stockable Trout Waters
- VI. Natural Trout Waters
- VII. Wetlands

The waters of SHEN are placed into three of these classes. Tributaries to the Rappahannock and James Rivers and the South Fork of the Shenandoah River are classified as mountainous zone waters (Class IV), except those specifically classed as stockable trout waters (Class V) or natural trout waters (Class VI). No waters within SHEN have been formally identified as impaired, although long-term acid-base streamwater chemistry data collected under SWAS suggest that several park streams likely qualify for impaired stream (303[d]) listing per the water pH data parameter.

Virginia's antidegradation policy classifies water quality at three levels or "tiers":

- Tier 1 specifies that existing in-stream water uses and the level of water quality to protect the existing uses shall be maintained and protected. This means that, at a minimum, all waters should meet adopted water quality standards.
- Tier 2 protects water that is of higher quality than specified water quality standards. Only in limited circumstances may water quality be lowered in these waters.
- Tier 3 includes exceptional waters for which new, additional, or increased discharge of sewage, industrial wastes, or other pollution are not allowed. These waters must be specifically listed in the regulation.

Currently, none of SHEN's streams have been designated by Virginia as Tier 3, or Outstanding National Resources Waters, to be afforded special protection under anti-degradation provisions of the Clean Water Act. In 2002, however, SHEN evaluated and submitted comments on several park streams proposed by Virginia for Tier 3 designation.

## **7. Wilderness Act**

The Wilderness Act of 1964 established the National Wilderness Preservation System, composed of Federal lands designated as Wilderness Areas where visitors have the opportunity for solitude, study, and experience in a natural area. Wilderness is an area where:

"the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain...an area of undeveloped Federal Land retaining its primeval character and influence...which is protected and managed so as to preserve its natural conditions" (16 USC 1131(c)).

In October 1976, Congress designated over 40% of SHEN (79,019 ha or 195,256 ac) as Wilderness. An additional 227 ha (560 ac) was designated as Wilderness in September 1978. The Wilderness Act and its implementing regulations charge Federal land management agencies to preserve the wilderness character of such areas under their jurisdiction, and to protect them from human-caused effects not specifically allowed by law. The Wilderness Act and implementing regulations do not directly address air pollution effects; however, they do specify what should be protected in Wilderness (the earth and its community of life) and to what degree (preserve natural conditions). Within this context, each component of the Wilderness resource is important in itself, as well as in terms of how it interacts with other ecosystem components. Acid-sensitive watersheds and streams having low acid neutralizing capacity (ANC) within the park are primarily located within designated Wilderness. Air pollutants have significantly altered the park's natural visibility conditions, biogeochemical processes, and biodiversity of acid-sensitive streams, and also threaten terrestrial ecosystems.

## **8. Other Pertinent Laws**

Several other laws are summarized here because they provide pertinent resource stewardship mandates to the park. Scenery is fundamentally important to the purpose and national significance of SHEN, home to more miles of the Appalachian National Scenic Trail than any other national park. The Federally-endangered Shenandoah salamander (*Plethodon*

*shenandoah*) may be at risk from acidic deposition effects. It is important to restore visual air quality and protect the park's cultural landscapes and cultural resources either placed on (e.g., Skyline Drive) or determined eligible for (e.g., Appalachian National Scenic Trail), the National Register of Historic Places.

The 1968 National Trails System Act established a national system of recreational and scenic trails to provide for the ever-increasing outdoor recreation needs of an expanding population and to promote enjoyment and appreciation of the open-air, outdoor areas of the nation. Congress designated the roughly 2,100-mile (3,380 km) Appalachian Trail and the approximately 2,350-mile (3,807 km) Pacific Crest Trail as the initial National Scenic Trail. The 101-mile (155 km) portion of the Appalachian National Scenic Trail within SHEN was constructed along the crest of the Blue Ridge between 1926 and 1936. Today, the Appalachian National Scenic Trail forms the backbone of SHEN's trail system. It includes fine examples of early trail construction techniques and is the longest segment of the Appalachian National Scenic Trail within a national park.

The 1973 Endangered Species Act (Amended in 1978, 1982, and 1988) was enacted to provide effective, long-term protection for threatened and endangered species. The Shenandoah salamander, a small terrestrial salamander found only within SHEN, was listed as endangered by the Commonwealth of Virginia in October 1987 (Wynn 1991), and was designated as Federally endangered in August 1989 (54 FR 34464). Initially, the Shenandoah salamander was believed to be endangered exclusively by natural biological causes (e.g., competition with the red-backed salamander, *Plethodon cinereus*), indicating that this species would not benefit from preparation of a recovery plan. However, key human-related factors affecting SHEN, such as acidic deposition and forest defoliation associated with exotic insects, prompted the USFWS to prepare a recovery plan in cooperation with the NPS. The 1994 recovery plan also addressed routine park management and permitted activities (e.g., trail maintenance, fire management, camping), in order to minimize potential human impacts to the species.

The 1966 National Historic Preservation Act authorized the Secretary of the Interior to "expand and maintain a national register of districts, sites, buildings, structures, and objects significant in American history, architecture, archeology, and culture". In 1996, Skyline Drive and 69 historic overlooks along its 105-mile length, as well as associated developed areas at Simmons Gap, Lewis Mountain, Big Meadows, Skyland, Piney River, Pinnacles, Dickey Ridge, Park Headquarters, Elkwallow and South River Picnic Campground, Camp Rapidan, Corbin

Cabin, Mount Vernon, Iron Furnace, and the Shenandoah cultural landscape, including the 101-mile segment of the Appalachian National Scenic Trail, were placed on, or determined eligible for, the National Register of Historic Places. National significance of the Skyline Drive and Park Headquarters cultural landscapes reflects their association with the Civilian Conservation Corps, the Works Progress Administration, and the presence of several hundred architectural and landscape structures and features. The park's Strategic Plan includes a long-term goal to clear and maintain vegetation obscuring views from historic overlooks along Skyline Drive. Improving visual air quality by reducing haze-forming air pollution is an important complementary goal to restoring and protecting scenic, natural, and cultural resources and landscapes at SHEN.

## **9. National Park Service Management Policies**

In carrying out their responsibilities under the 1916 National Park Service Organic Act and other pertinent statutes, all NPS officials and employees must be knowledgeable about the laws, regulations, and policies that pertain to their work. The NPS, like other Federal agencies, develops policy to interpret the ambiguities of the law and to fill in the details left unaddressed by Congress in statutes. Agency policy must be consistent with the Constitution, public laws, Executive Orders, and all other higher authorities.

The NPS Management Policies 2001 clarifies that the fundamental purpose of the National Park System established by the Organic Act begins with a mandate to conserve park resources and values (National Park Service 2000a). When there is a conflict between conserving resources and values and providing for enjoyment of them, conservation is given priority. The Management Policies prohibit impairment of park resources and values unless directly and specifically provided for by legislation or by the proclamation establishing the park. The Management Policies also recognize that parks are integral parts of larger regional environments, thereby increasing the importance of constructively managing external threats from non-agency as well as agency activities. Air resource management policies are summarized below:

- Seek to perpetuate the best possible air quality in parks to preserve natural and cultural resources, and sustain visitor enjoyment, human health, and scenic vistas
- Embrace affirmative responsibilities to protect AQRVs in Class I areas
- Proactively help states (and interested Tribes) achieve the National Visibility Goal

- Strive to protect integral vistas (specific views from Class I areas to outside the boundary of the Class I areas) through cooperative means
- Take advantage of opportunities to protect air quality in Class II areas
- Integrate air resource management requirements into NPS operations and planning to ensure environmental compliance of in-park air pollution sources
- Acquire and evaluate information needed to effectively participate in decision-making that affects park AQRVs
- Participate in the development of Federal, state, and local air pollution control plans and regulations
- Participate in permit application reviews for major new or modified air pollution sources and develop recommendations to permitting authority to mitigate adverse impacts
- Promote public understanding of park air quality issues through educational and interpretive programs

#### **D. SCOPE**

This report is based on a concern for the scenic resources, cultural landscape, and ecological integrity of SHEN. The legal and policy foundation, described above, addresses the pertinent Federal mandates and guidance that must be considered in upholding the NPS affirmative responsibility to restore and protect AQRVs in SHEN, which include water, aquatic biota, soil, vegetation, and visibility. The scientific foundation and scope are generally limited to addressing these known AQRVs and the key air pollutants that threaten: 1) aquatic resources (primarily from S and N deposition), 2) terrestrial resources (primarily from O<sub>3</sub> exposure and N and S deposition [including gaseous form]), and 3) visibility (primarily from fine particles suspended in the air). Estimates of the isolated effects of ground-level O<sub>3</sub> on trees and forests and acidification effects on aquatic biota may be conservative because they did not consider effects from other, potentially exacerbating, stresses. Exposure to trace metals, pesticides, radionuclides, and organic toxins are not addressed.

The fine particulate matter standard set by the U.S. EPA to protect public health and welfare is not addressed because, barring substantial increases in SO<sub>2</sub> or NO<sub>x</sub> emissions in key states or source subregions affecting the park, SHEN air quality will likely meet this standard. Nitrate air concentrations are not addressed for visibility effects due to time and funding constraints and the

current dominant role of sulfate air concentrations. However, nitrate air concentrations would increase in relative importance under any air pollution control strategy that calls for substantial reductions in SO<sub>2</sub> emissions beyond the 1990 CAA. This assessment focuses on regional or uniform haze attributable to haze-forming emissions from numerous distant and local sources over a wide geographic area. Visibility degradation can also be caused by local sources and specific meteorological conditions that result in coherent plumes or layered hazes observed from park vistas. However, plumes and layered hazes are usually evaluated on a case-by-case basis, and robust data sets needed to support such analyses are generally not available.

The Enhanced Regional Acid Deposition Model (RADM) was selected for atmospheric modeling, in part because it was published and fully operational for strategic atmospheric modeling applications at the onset of this project. Time and funding constraints prohibited the supplementary use of the CALPUFF model for higher resolution in the park's local modeling domain. Critical loads are threshold amounts of pollutants at which specific potentially harmful effects on sensitive resources begin to occur. Target loads are pollutant levels at which it is believed that the environment will be protected to a specified level and/or over a specified period of time. Critical load ranges for N deposition are not addressed in this report, in part due to modeling limitations. Target loads entail policy decisions by the NPS and are therefore beyond the scope of this assessment.

Although the report attempts to assess many of the critical issues facing the park, partial coverage or absence of coverage of some topics should not be interpreted as a judgment that these topics are not important or relevant to the issue of air pollution effects. These omissions often reflect the lack of information on these topics rather than any reflection on their scenic or ecological significance.